HOW TO PROTECT FOOD & SEED GRAINS FROM INSECTS, RATS & MOULDS

MINISTRY OF AGRI.

C.F.T.R.I.

How to protect food and Seed grains from Insects, rats & moulds.

Ministry of Agriculture
Govt. of India
1949.

CONTENTS

PREFACE

If foodgrains, which are produced at a heavy expense by employing various improved methods of agriculture are to be available for the sustenance and nourishment of the ever-increasing population of India, their proper storage must receive attention. Special care has to be taken in farm stores and in *mandi* godowns, as it is at such primary stages of storage that insect infestation starts and gets built up in big stores. The problem of seed storage is still more important than even that of foodgrains. Almost all store pests start their attack from the germ point of the grain, thus resulting in very serious injury to its propagation value, often resulting in the total loss of its viability.

The annual loss in tonnage is estimated at about 2·5 millions—about 5 per cent. of our total production. This is not an overestimate; in fact the International Conference organized by the F.A.O. in London in 1947 concluded that in tropical and sub-tropical countries like India of which the climate is conducive to rapid pest multiplication, the loss is more than 10 per cent. which is the average for all parts of the world taken together. It is noteworthy that even at the rate of 5 per cent., the loss in India is roughly equal to the minimum deficiency in our food production which is made up by imports at heavy expenditure. Main sources through which the loss occurs are insects, rats and dampness. Such serious losses can be considerably reduced if not entirely prevented. In some parts of India, some measures have been taken but they have been mostly confined to Government godowns in which only a very small proportion of the produce of the country is handled and that too against insects only. Unfortunately, very little attention has been paid to check losses in village and

trade stores where actually, as stated above, the infestation starts. Methods by which the losses in small stores can be reduced to a great extent are described in this Brochure. Detailed information on any aspect of grain storage can be had from the Directorate of Plant Protection, Quarantine and Storage, Ministry of Agriculture, New Delhi.

NEW DELHI;
January, 1949.

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I. ENEMIES OF FOOD AND SEED GRAINS

(a) Insects :

Many people believe that the appearance of insects in stores is spontaneous and therefore a necessary and unavoidable evil. This is wrong. Insect infestation can only result from eggs laid by parent insects already present in the godown or those insects which enter the godown after the grain has been stored, or those which attack the crop when the grains were maturing in the field before harvest. These main sources are briefly described below :—

(i) *Field infestation*.---Some insects, like the Rice weevil or Pulse beetles, lay eggs on ripe grain in the field and their young ones are carried into the stores along with the grain. The presence of such infested grains in the store is not noticed until the adults appear a few weeks later. It is on this account that ignorant villagers and grain dealers are led to believe that such pests appear spontaneously in the stores.

(ii) *Infested stores*.—It generally happens that when the stores are emptied, some insects are left behind. They live on spilled grain or bits of grain which accumulate in cracks and crevices. These insects thus have facilities for breeding and multiplying, and the infestation is carried over to the fresh stocks when they are placed in such stores. It often happens that in the rush of work entailing rapid handling and moving of grain stocks, the cleaning of stores before storing the fresh stocks is overlooked. Sometimes the fresh stocks are placed by the side of the infested one and thus the infestation easily spreads from the infested to the clean grain and

results in the contamination of the entire stock. Similarly, insects from a store containing infested stocks, may migrate by flight or by crawling into a neighbouring store containing clean stocks.

(iii) *Infested bags.*—Many insects, especially the *khapra* larvae, remain lodged in the meshes and seams of bags when they are emptied of grain. If such bags are again filled up without cleaning, the insects which remained in the meshes of the bags become active and attack the new grain.

(iv) *Infested vehicles used for carrying grain.*—Fresh infestation also occurs in unclean railway wagons, lorries, trucks or boats which are used for carrying grain Similarly, insects become established under the floor boards or in crevices of lorries, boats, etc., and when these are used for the transportation of clean grain, the stock picks up the infestation.

(b) RATS ·

Grain in storage is also liable to raids by rats. Rats can gain access through any openings in the building or by burrowing their way through *kuccha* floors, and become a constant menace in the store. Not only do they consume and contaminate nation's food but also transmit diseases to humans. It is estimated that 20—25 rats eat in one day about one pound of food which is enough to keep a normal man active. The total population of rats in India was reported in 1922 to be double of the human population, causing a total annual loss in various ways amounting to about sixty crores of rupees. It is, therefore, vitally necessary to take all possible steps for the destruction of this pest.

(c) MOISTURE :

Stored grain is also subject to serious deterioration due to moisture. There is a very close relationship

between the moisture content of grain and the degree of atmospheric humidity. Because of the hygroscopic nature of the grain, it may acquire a moisture content which is sometimes even higher than the safe limit of 10—12 per cent. This is particularly true of the grain stored in bags. Grain, having high moisture content, is liable to develop local 'heat pockets' due to excessive respiration. Heat thus evolved raises the temperature of the grain. Unless the heat and excessive moisture are removed by quickly turing over the stock, this self-accelerating process of 'heating' will continue until the grain acquires a characteristic smell and becomes unfit for human consumption.

Similarly, when grain is heavily infested, conditions similar to those explained above are produced which induce excessive respiration of the grain and rise in its temperature.

Apart from the 'heating' of grain, insects, mites and moulds reproduce and multiply more rapidly under humid conditions and therefore cause heavier damage than in dry grains.

II. STORE INSECTS AND THEIR GENERAL HABITS

There are more than one hundred species of injurious insects of which, however, only about two dozens do serious damage to stored grains. The most important of these pests are illustrated in Plates I and II, and are briefly described below :—

The Rice Weevil[1], popularly called *sundwali susri*, is a tiny beetle with a long snout. It is reddish-brown in colour and has four light reddish patches and round pits on the back (Plate I, Figs. 1 and 2). It feeds both in its young and adult stages and attacks all kinds of grain.

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[1]*Sitophilus oryza.*

The Lesser grain borer[2] is slightly smaller than the 'Rice Weevil' and is dark brown or black in colour (Plate I, Figs. 3 and 4). Both its young and adults feed on all kinds of grain.

The *Khapra*[3] beetle is light brown in colour, of stout built and is oval in shape (Plate I, Figs. 5, 6 and 7). The damage by this pest is mostly caused in its larval stage. The newly hatched larva begins feeding on the soft germ point of the grain and continues feeding deeper into the kernel as it grows.

The Flour bettle[4], popularly called *susri*, is dark or reddish brown in colour and flattened in shape (Plate I, Figs. 8 and 9). It is a serious pest of processed and milled products such as *utta*, *maida*, etc. It also feeds both in the young and adult stages but rarely on whole grain.

The Pulse beetles[5] commonly known as *dhora*, are small, heart-shaped insects with a small head having a blunt rostrum (Plate II, Figs. 6 and 7.) The most serious species are *Bruchus chinensis* and *B. analis*. Pulse beetle attacks all kinds of pulses.

The Grain moth[6] is a serious pest of whole grain. The moth is light-tan in colour and has narrow wings fringed with short hair. The larva is whitish in colour with yellowish head. It passes its life inside the grain feeding on the kernel (Plate II, Figs. 1 and 2).

The Rice moth[7] is pale-greyish brown in colour (Plate II, Figs. 3 and 4). The larva is dirty white, and lives in tubes made up of silk reinforced by powdery matter and broken grain woven into a mass. The moth spoils more grain and renders it unfit for human consumption than it actually eats.

The Indian meal moth[8] is a beautiful moth, having reddish brown markings on the forewings with a coppery

[2]*Rhizopertha dominica*. [3]*Trogoderma granaria*. [4]*Tribolium castaneum*. [5]*Bruchus chinensis* [6]*Sitotroga cerealella*. [7]*Corcyra cephalonica*. [8]*Plodia interpunctella*.

PLATE I

Fig. 1
Sitophilus oryza—weevil.

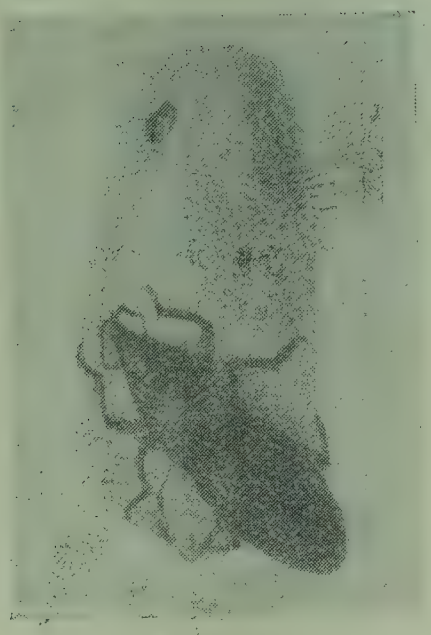

Fig. 2
Sitophilus oryza—weevil feeding on grain.

Fig. 4
Rhizopertha dominica—pupa inside the grain.

Fig 3.
Rhizopertha dominica—beetle.

Fig. 5
Trogoderma granaria—khapra beetle.

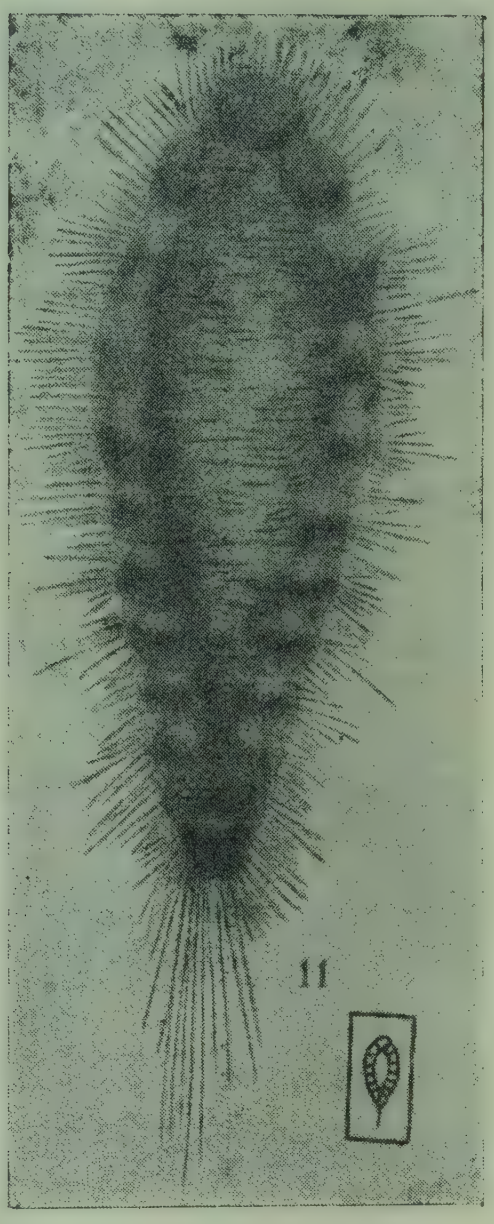

Fig. 6
Trogoderma granaria– khapra larva.

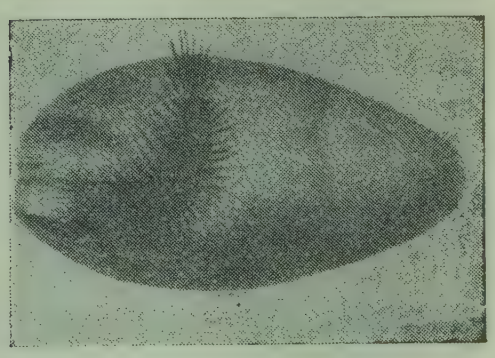

Fig. 7
Trogoderma granaria—khapra larva feeding on grain.

Fig. 8
Tribolium castaneum—beetle.

Fig. 9
Tribolium castaneum—larva.

PLATE I

Fig. 1
Sitotroga cerealella—moth.

Fig. 2
Sitotroga cerealella—larva resting as pupa inside the grain (cut open) after eating out the kernel.

Fig. 3
Corcyra cephalonica—moth.

Fig. 4
Corcyra cephalonica—larva.

Fig. 5

Plodia interpunctella.—moth.

Fig. 6

Bruchus chinensis—moth.

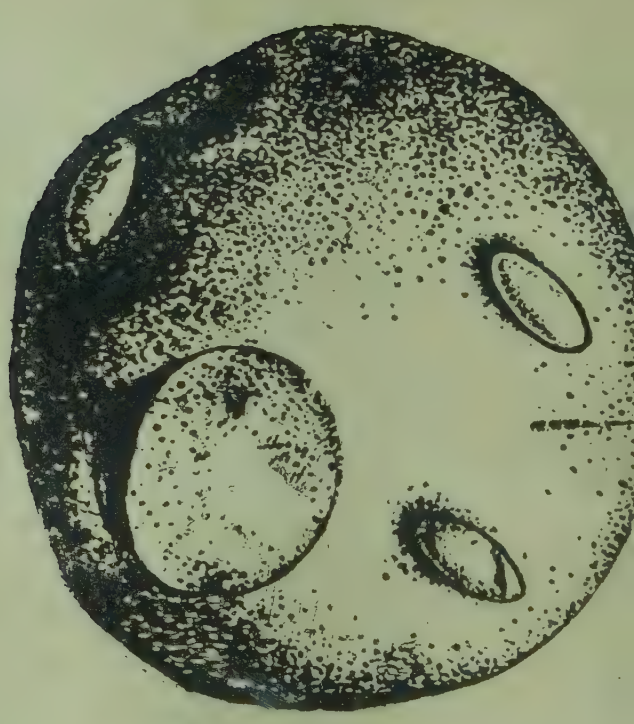

Fig. 7

Grain showing eggs of *Bruch*
laid on its surface and the emerge
hole through which adult came out

lustre on the outer two-thirds and whitish grey on the inner portions (Plate II, Fig. 5). It feeds on all kinds of whole grain or milled cereals. In serious infestations, bags of grain get covered with an extensive sheet of silken material spun out by the caterpillars.

Besides the insects named above, Meal worms, Black fungus beetles, and the Fig moths are generally present in dark, damp and dingy stores and feed on the grain which is 'out of condition'. Their presence itself indicates that the hygienic condition of the stores is unsatisfactory.

Habits of store insects

Various insect pests lay 100—500 eggs—either on grain, among the food particles or among the debris lying accumulated in cracks or crevices in stores. Eggs are generally minute and of whitish colour. They hatch into tiny larvæ within a week or so. They may bore the grain and pass their life inside or they may live among them. The larvæ of most moths and some beetles form a cell or cocoon inside which they pupate and remain in the pupal stage for about 10 days before emerging as adults. A single life-cycle, from egg to adult, is usually completed within about four weeks, but it sometimes varies considerably depending on weather conditions and season. For instance, *khapra* may take four years to complete its life-cycle in the absence of food or under other adverse conditions.

Store insects usually breed and multiply rapidly, especially under warm and moist conditions. Often all stages of insects can be seen in the same food material and in the same godown. They can breed continuously in the same grains for a number of years, particularly when the grains are held over a long period without any frequent turn-over.

Detection of insect infestation

Presence of insects in a store can be detected by the following :—

(i) Patches of loose plaster on walls behind which insect larvæ (*e.g. khapra*) are or have been resting.

(ii) Small holes, cracks and crevices in walls, floors and ceilings in which insects usually lodge themselves.

(iii) Webbings on the walls, in corners and sometimes even on the ceilings, etc.

(iv) Patches of white powdery material on the bags of grains. These are produced as a result of the insects eating on the kernels of grain inside and throwing out fine particles of grain, flour material, etc.

(v) Unusually warm grain may indicate heavy insect infestation.

(vi) Grain injured at the embryo end or irregular patches on the surface of the grain produced as a result of the eating by insects.

(vii) Unpleasant smell and moist heat emitted by stored grain. This is felt as one enters a store which had remained closed for some time. It is a special sign of the 'heating' of the grain even if the insect infestation is not yet severe.

III HOW TO IMPROVE STORAGE CONDITIONS

A. Improvement of Indigenous Methods of Storage

In Indian villages grain is mostly stored in bulk in a variety of receptacles. These receptacles are often simple but sometimes ingenious in their construction. They vary in shape, capacity, etc., depending on climatic conditions of the area, kind and quantity of grain

PLATE III

Fig 1.
An opening of *kucha Khatti*.

Fig. 2.
An opening into one of the concrete *Khattis* showing the iron lid.

required to be stored, local conventions and lastly, the availability of building material. Below is given an account of the typical methods of storage, their drawbacks and how they can be improved :—

(a) *Khattis and other underground receptacles*

Storing of grain in *khattis* is common throughout the U.P., Rajputana and some parts of C.P. In big *mandis* like Hapur and Shamli, *khattis* are used for storing grain for long periods. A *khatti* (Plate III, Fig. 1) is an underground pit. with a circular opening at the top which is about $2\frac{1}{2}$ feet in diameter, enough for a man to go in. It is usually about 16 feet deep, and has a capacity of about 600 maunds. In some parts of India, before putting the grain inside a *khatti*, a layer of *bhusa* (wheat straw) is placed all round between the grain and the walls and on the bottom. When full, a layer of *bhusa* or dust is also placed on the top layer of the grain and the opening is closed and plastered with mud in flush with the surface of the ground.

Banda is a form of *khatti* commonly used in C. P. It is about 15 feet deep, the breadth, in many cases, may be greater than the depth. Sometimes walls and the bottom are made of masonry.

Pev is also an underground pit which is common in the Sholapur, Satara, Poona and Ahmednagar districts of the Bombay Presidency. It has a square or circular opening at the top which is made slightly below the ground level.

Targhar is also an underground structure like *khatti* provided with a lid-like door. This is common in the Deccan.

Khas or *khai* is an underground, well-like structure about 18 feet deep, which is very common in Rajputana

The most serious defect of the *khatti* type of storage is that grain if stored for long time absorbs moisture

from the walls, gets discoloured and usually becomes unfit for human consumption. Such losses due to moisture have been estimated at about 2—5 per cent. In humid areas, *bhusa* provides very little protection to stored grain against moisture. Moreover, grain stored in *khattis* may be liable to raids by rats through underground burrows.

Khattis can be improved to a great extent by preventing seepage of moisture through its walls. To ensure this, *khattis* should be built only at places where the subsoil water level is very low. Further, their inside should be given one and a half brick deep lining all round, and thinly plastered over with pond's clay if cement is not available. This will also prevent rat attack. In drier areas, a thick lining of straw all round will serve the purpose to a very great extent. The man-hole should be provided with a cover or lid-like door, preferably of iron, to prevent rats gnawing their way through the door (Plate III, Fig. 2).

Where practicable, partially underground and partially above-ground or wholly above-ground *khattis* made of bricks would be the most suitable structures. Partially underground and partially above-ground *khattis* have been built by some local grain merchants in the U.P. But an ideal underground *khatti* would be one made of cement concrete. Some big Zamindars in the U.P. have also built such structures for their own use.

Some years ago the "Grain trade Chamber" of Muzaffarnagar (U.P.) replaced some years back their *kuccha khattis* by cement concrete *khattis* (Plate III, Figs. 2 and 3) which are insect, damp and rat proof. Grain stored in them is reported to have remained absolutely free from any damage or weeviling even after 16 months.

(b) *Mud-bins*

There are several types of bins which are used for storing grain. They are usually located inside the

PLATE IV

Fig. 1

Kothi made in pieces—common in Bihar.

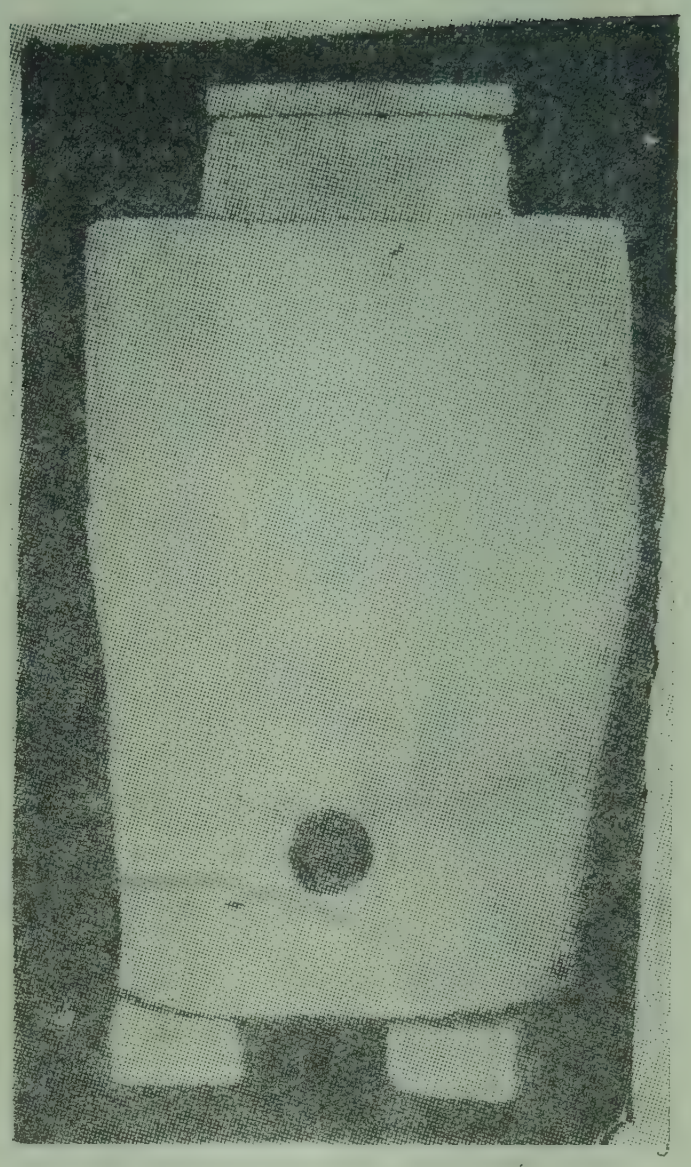

Fig. 2

Small *Kothi*—common in Bihar.

Fig. 3

Kothi made of unburnt clay—used in the Punjab.

Fig. 4

Bharoli—common in the Punjab.

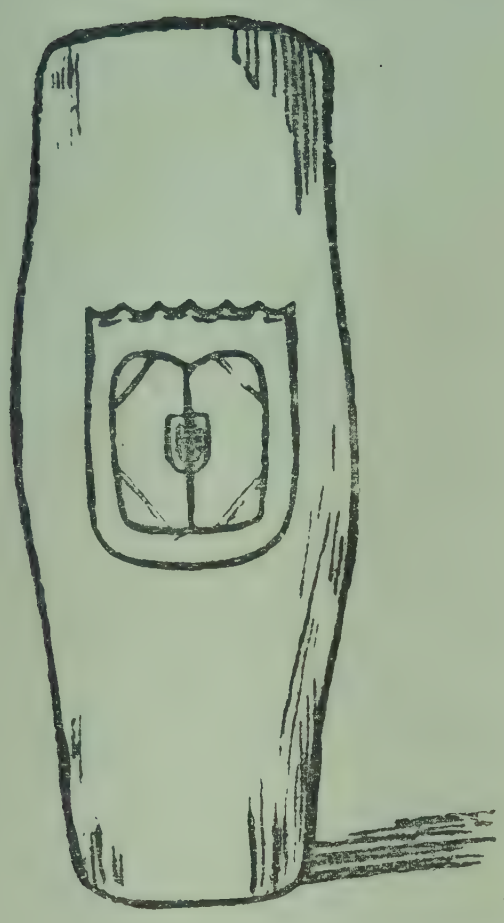

Fig. 5
Bharola (large size.)—common in the Punjab.

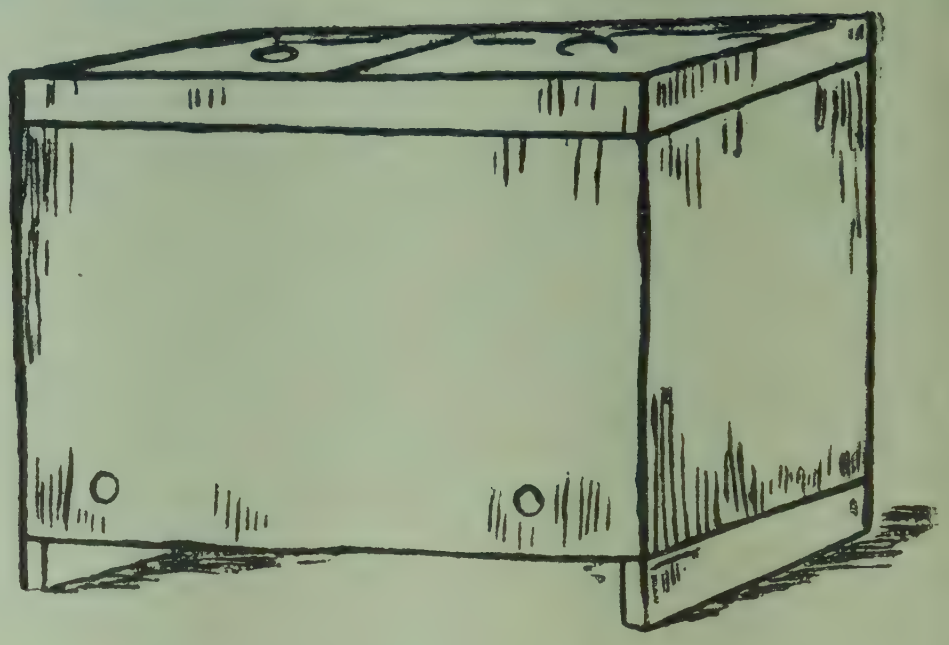

Fig. 7.
Petti—common in the Punjab.

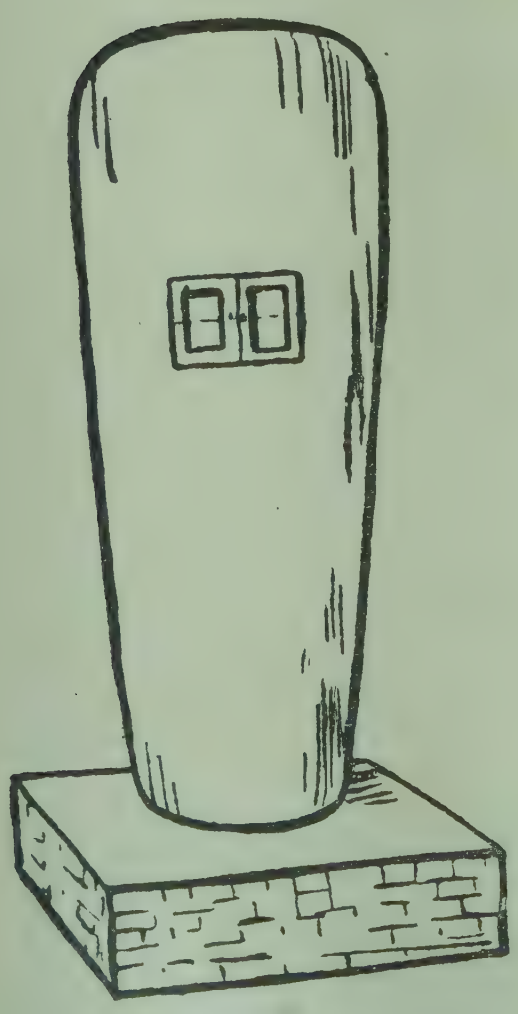

Fig. 6
Bharola (large size).—common in the Punjab.

Fig. 8
Gadi—common in Madras Presidency.

dwellings of villagers. A type of bins called *kothis*, made of unburnt clay, are common in Bihar. They are often oval in outline, with a small circular hole slightly above the base of the bin through which the grain can be taken out without opening the mouth at the top (Plate IV, Figs I and 2). The lid is usually of the same shape and material as the walls. Square and rectangular *kothis* are also made consisting of two or three sections joined to one another. The walls are generally $1\frac{1}{2}$ inches thick and are built bit by bit adding a new piece only when the lower one is dry.

In the Punjab and some parts of the U.P. and Rajputana, *kothis* (Plate IV, Figs. 1—3) also made of unburnt clay are in use. They are invariably oblong or square in outline and usually larger than those used in Bihar. Two or three inches thick walls are built bit by bit on a thick clay slab and are raised up to a height of 6—7 feet (capacity up to 500 maunds), depending upon the space available inside the house. The top is covered over with another slab of clay. If *kothi* is to be placed outside, a thatched shelter is provided to drain away the rain water. A *kothi* is sometimes provided with a small door fixed up with hasp and staples, so that it can be shut or opened when required. A small circular hole is also provided near the base through which grain is taken out when required without opening the door. This hole is usually kept plugged with gunny cloth, etc. A similar but slightly larger hole is provided near the top for pouring in the grain when its level goes above the door.

In many parts of India, *e.g.*, Punjab mud-bins called *bharolis or bharolas* (Plate IV, Figs. 4, 5, 6 and 7) are used for storing small quantities of grain. These are either oval or chimney shaped, with a small door in the middle, or are box-shaped called *petti*, provided with a lid. The bin has a small circular hole near the base, the lid being usually kept sealed.

In some parts of South India, granaries made of mud, called *gadi* are built (Plate IV, Fig. 8). They are usually raised above-ground by means of small wooden pillars or columns of bricks.

The above-mentioned structures are good for storing small quantities of grain for day to day use. If grain is kept for more than one season, it is always liable to deterioration on account of dampness, insects and rats. Joints and crevices in the bins built in sections provide ideal situations for insects for uninterrupted breeding. Moreover, mud-bins cannot be thoroughly cleaned as after the bulk of grain is removed, some grain is always left inside the granary on which insects continue breeding.

Rats also easily burrow into mud bins and not only do they spoil and eat the grain but damage the receptacles as well, thus causing spillage and waste.

There is very little that can be done to really improve the efficiency of mud bins. However, some degree of improvement can be effected by adopting the following measures :—

(i) The walls made of clay should be 4—6 inches in thickness, smooth and without any joints or crevices.

(ii) As far as possible, corners should be rounded off.

(iii) Small door covered over with tin should be provided near the base in place of the circular hole. This will help a good deal in cleaning the lower part of the granary effectively, which otherwise is not easily accessible.

(iv) In the case of *kothis*, the floor should be raised above the ground level so that the access of moisture from the ground is prevented. It may be built on pillars 2′—3′ high or plinth of the same height.

(v) A 9-inches wide ledge of ordinary tin extending outwards should be provided at the base of

the *kothi*. This will guard to some extent entry of rats.

The most ideal structures would be *pukka* bins, made of cement concrete or brick masonry, plastered over with cement. Wooden bins with proper rat-proofing arrangements such as provision of tin ledge, etc., can also be a satisfactory substitute. The improved bins may be built as a single unit or a battery of them with a common shelter above. The shelter may be a thatched roofing thickly covered over with clay or built of tiles. Brick masonry structures are more lasting. They can better be put up by Co-operative Societies and the individual producers should store their crops on small payments.

(c) *Bamboo and straw bins*

Granaries made of bamboo or straw are usually located outside the village dwellings. They are of various shapes. *Bukharis* common in Orissa, Bihar, Bengal and Assam, are built on a raised platform to avoid dampness. The walls of *bukharis* are usually made of stems of *ikri* or wattled bamboo, thickly plastered over with mud. The receptacle may have one to four chambers (Plate V, Fig. 3).

Other structures made entirely of straw are called *puras*, *morai*, *puttarai* and *kups*, etc. These are common in Bihar, Bengal, Madras and the Punjab. Storage of grain (mostly paddy) in *pura* (Plate V, Fig. 1) is merely preserving it in straw bundles which are placed inside the dwellings to protect them from rain. A similar method is followed in Konkan where this type of receptacle is known as *mudhas*. Grain up to 2 maunds can be stored in these structures.

A *morai* (Plate V, Fig. 2) is entirely made up of ropes of straw and built on a solid platform made either of earth or masonry. It is common in Bihar and parts of Bengal. First, a thick layer of straw is spread on the platform. On this some grain is poured round which

the *morai* is gradually built. The lowest ring is made of very thick rope. It helps to keep the straw standing erect which is intended for lining the *morai*. More grain is poured in and the rope taken round and round. Finally it is covered over with a conical thatched roof. A *morai* has a capacity of 200—800 maunds. Similar receptacles are prevalent in other parts of India. In the South, such structures are called *pattarai* (Plate V, Fig. 4) and in the Punjab called *kups*. *Kup* differs somewhat from *morai*, as it is entirely dome-shaped and the ropes are not so closely wound round it. *Pallis* (Plate V, Fig. 5) used in some parts of the Punjab are made of palm leaf. A mattress made out of these leaves is rolled round masonry platform and its ends are stitched together to make a drum-like structure. The lower end is tied to the platform with a rope. The top is usually covered with a thatched roof.

With due care, bamboo and straw receptacles described above, are capable of lasting about 8 years. The grain stored in such receptacles more often remains well ventilated and, therefore, free from heavy infestation except by rats.

The various straw structures made on platform can be guarded against rats by fixing all round the platform a tin sheet horizontally projecting out upto about a foot. This will prevent rats reaching the body of the *morai*. A similar ledge can be put round the base of *bukharis*. A good deal of protection against moisture coming from below can be afforded by building the platform at least 3 feet above-ground.

Generally, in all Indian villages, small quantities of grain are stored in *gharas*, *jalas* or *matkas*, often used for storing seeds. They are made of burnt clay. The earthen covers are sealed with mud after filling the container.

Fig. 2—Straw *Morai*—used in Bihar and Bengal.

Fig. 1—Straw *Pura*—used in Bihar and Bengal.

Fig. 3—*Bukharis* common in Bihar and Assam.

Fig. 4 —*Pattarai*—common in Madras Presidency

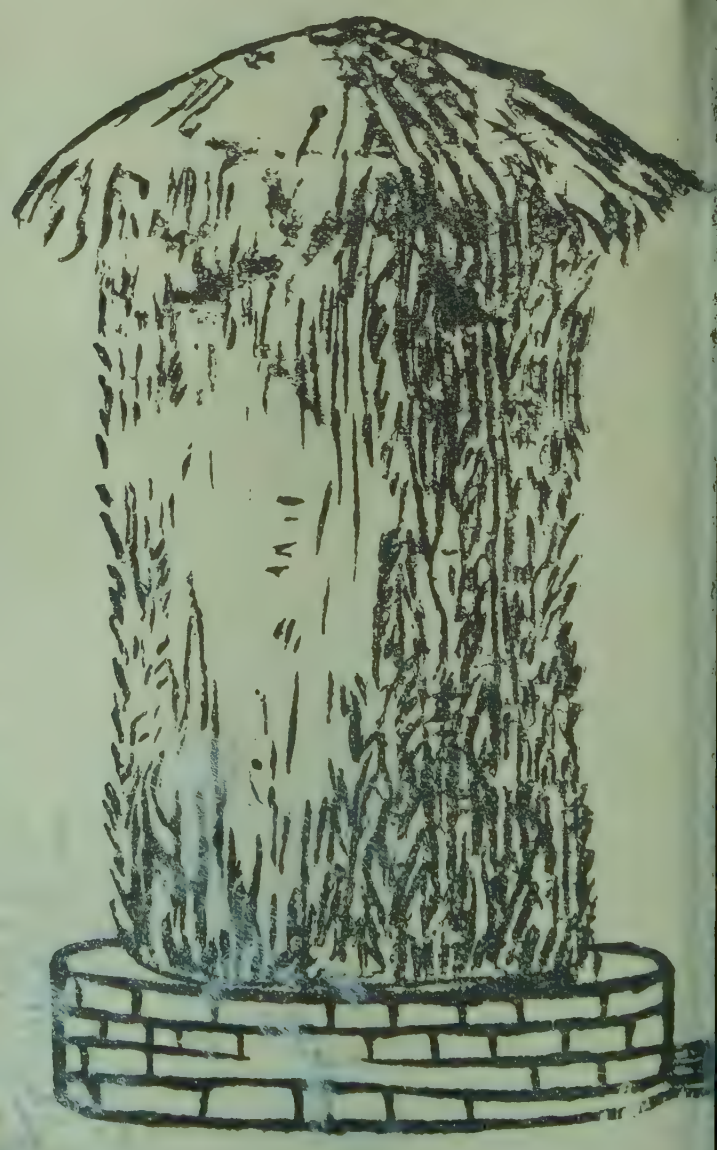

Fig. 5—*Pathi* – common in the Pun

Kerosene tins, or oil barrels with proper lids are also satisfactory substitutes.

Other measures essential to keep the grain in sound condition in village granaries are summarised below :—

(i) Threshing yard should be very clean of all faecal matter or rubbish and situated at a distance from the granaries.

(ii) Grain after harvest should be allowed to "cool" before storage, as immediately after harvest the grain is always warm.

(iii) Before storage the grain should be thoroughly dried in the sun.

(iv) The storage receptacle should be cleaned as far as practicable of all old left-over grain, weevils, etc., if any.

(v) The grain should be taken out of the receptacles after the rainy season and spread out in the sun. This will help to kill most of the insects, if there are any, and bring down the moisture content of the grain

B. Improvement of Storage Conditions in *Mandis*

With the movement of a large proportion of the crop from villages to the *mandis*, especially during the months immediately after harvest, the storage work in *mandis* and markets assumes special importance.

In *mandis*, grain is kept mostly in bags on account of the convenience in handling the stock. Sometimes loose heaps are built up even in an ordinary room with a dam of bags at the free end. Storage of foodgrain in bulk should be preferred to bag storage. But full advantage of bulk storage of grain can only be taken if dry and uninfested grain is stored in dry and clean stores.

Some grain dealers store bagged grain in '*kothas*' (small rooms) or any portion of their residential buildings. In some markets *kothas* are available on rent. Those dealers who have to handle large quantities of grain, have built ordinary *pukka* stores.

'*Kothas*' are very unsatisfactory for the purpose of storing grain. They are generally dark and dingy, and often kept in bad state of repairs. Therefore, the stored grain is subject to the depredations by insects, rats and moulds. In some *mandis* like Hapur where grain is stored in *kuccha khattis*, grain gets moist, discoloured and acquires bad smell.

(a) Bag storage and specification of a good store

For the reasons already explained, bagged grain is liable to easily pick up insect infestation and build up high moisture content. The stores should, therefore, be well-lighted and ventilated. Other specifications of a good store are:—

Foundation.—It should be three feet deep below the ground level or where this is not possible, the plinth or floor should be raised about two feet above the ground.

Ledge.—One foot ledge should be provided at the upper edge of the plinth, projecting horizontally outwards. The undersurface should be hard and smooth.

Floors and walls.—These should be made of concrete or stones or bricks in cement. If such materials are not available, walls may be built of bricks which should be well plastered over and finished with a coat of waterproof material.

Ceiling.—When corrugated iron sheeting is used for roofing, it is desirable to provide ceiling. This will be useful if fumigation has to be carried out.

Doors.—They should fit well, leaving no gaps and be capable of being opened from outside. To prevent

entry of rats, a tin strip should be fitted along the bottom four inches of the doors passing the lower end of the strip below the door to the other side and nailed (Plate VIII, Fig. 1). Iron sheeting between the wooden door frame and masonry will also prevent rats or white-ants burrowing through into the store.

Windows.—They should open outside and be about 3 feet above ground level. If this is not possible, half-inch wire netting should be fitted on the window. This prevents rats entering stores through windows.

Ventilators.—These should be well-fitted and capable of being opened from outside.

Drain pipes.—Lower openings of drain-pipes should be covered with well-fitted wire-netting or perforated metal sheeting.

Grain or grain products kept in such stores as described above should remain free from infestation by insects, rats, etc., but this can be fully achieved only if the stores are carefully inspected before and during storage and the following points are properly attended to :—

(i) The store before use should be swept thoroughly clean, ceilings cleared of any webbings and if necessary the stores be white washed. Where possible, cleaning should be done with electric cleaner, as it will clear out all rubbish from cracks or other situation otherwise inaccessible. Dust and webbings, if any, can be sucked out by this cleaner.

(ii) All cracks, holes, depressions on walls, floors, and ceilings should be levelled up and loose patches of plaster scrapped off and replaced.

(iii) Large holes in floors (mostly made by rats) should be filled up with sand or cement containing pieces of broken glass

(iv) All sweepings or old gunnies should be removed from godowns and burnt. No spilled grain should be allowed to lie on the floor.

(v) Stack bases should be marked out on the floor.

(vi) Timber battons (Plate VI. Fig. 1) should be laid on the area of the stack base as dunnage to keep the bags off the floor. If they are not available, loose bricks or ballies may be used.

(vii) Stacks should not be higher than 15—18 bags, depending upon the height of the godown and the space available. In any case, about 20 per cent. of the total space should be allowed between the top layer of the stack and the ceiling.

(viii) Each stack should be separated from the wall and from its neighbour by an alleyway of 1½ to 2 feet to allow for ventilation and proper inspection (Plate VI, Fig. 2). *Stacking bags in a haphazard manner* Plate VI, Fig. 3) *or against walls is dangerous.*

(ix) As far as possible, each stack should have one kind or grade of grain.

(x) Proper ventilation should be allowed in stores. During the monsoon weather ventilators should be kept open on dry days only.

(xi) Stocks should be frequently inspected, at least once a month and during heavy monsoon once a fortnight, but rooms should not be kept open for long periods during rainy weather. Small patches of powdery material indicate heavy infestation. If none is obvious on the outer layers of bags, a few bags on the top should be turned and the next layer examined.

PLATE VI

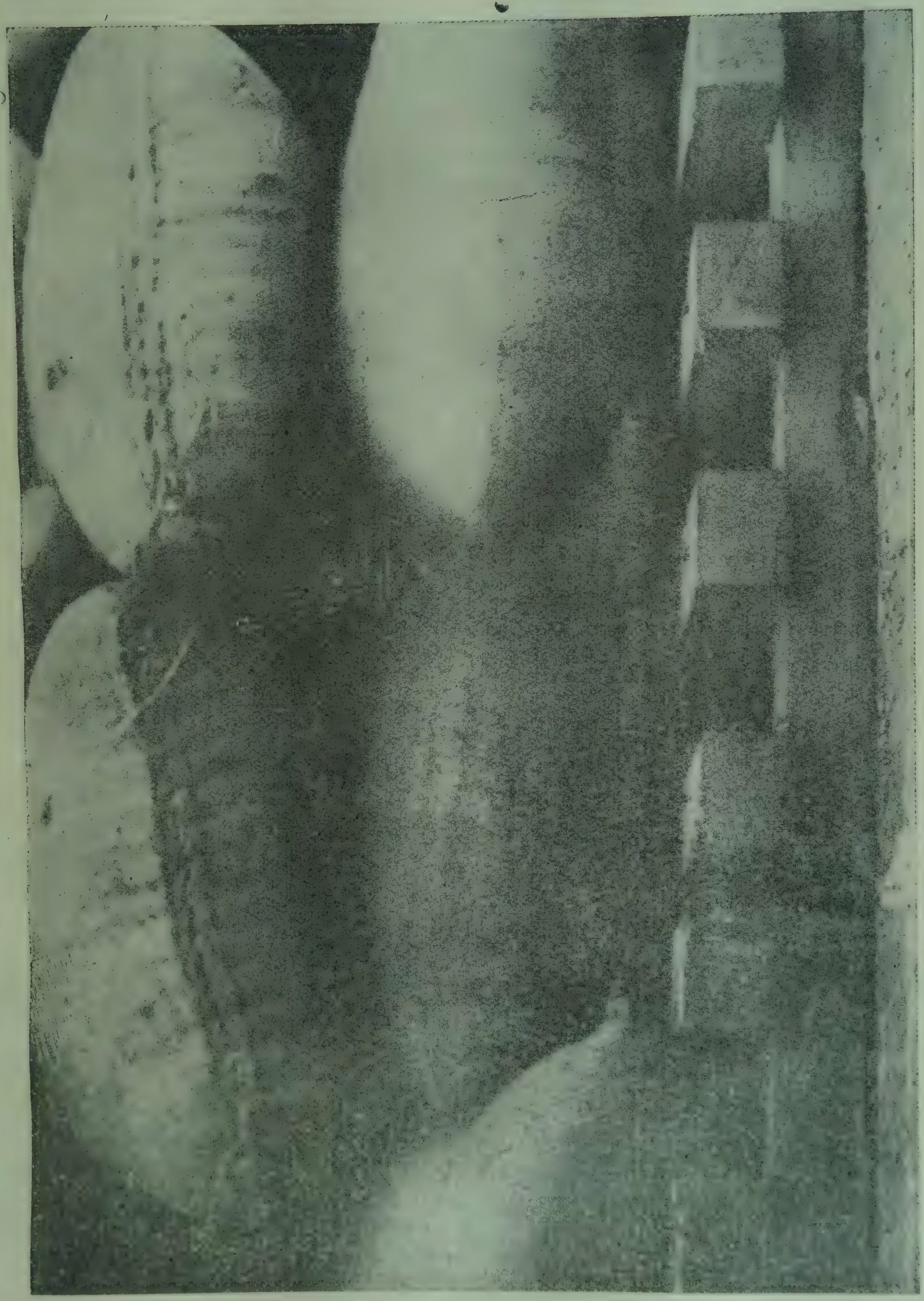

Fig. 1.
Timber battens a dunnage.

PLATE VI—*contd.*

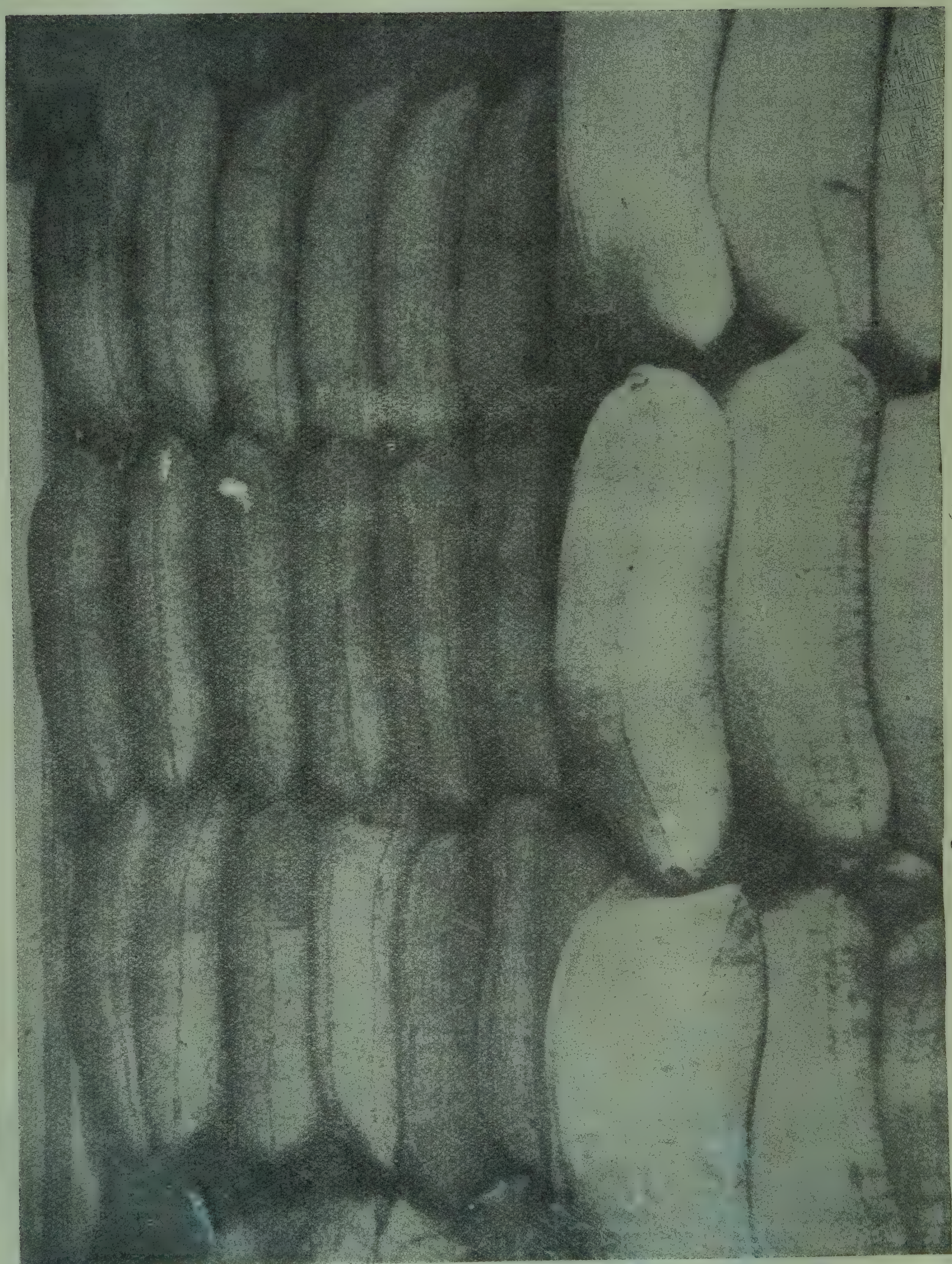

Fig. 2.
Proper way of stacking bags.

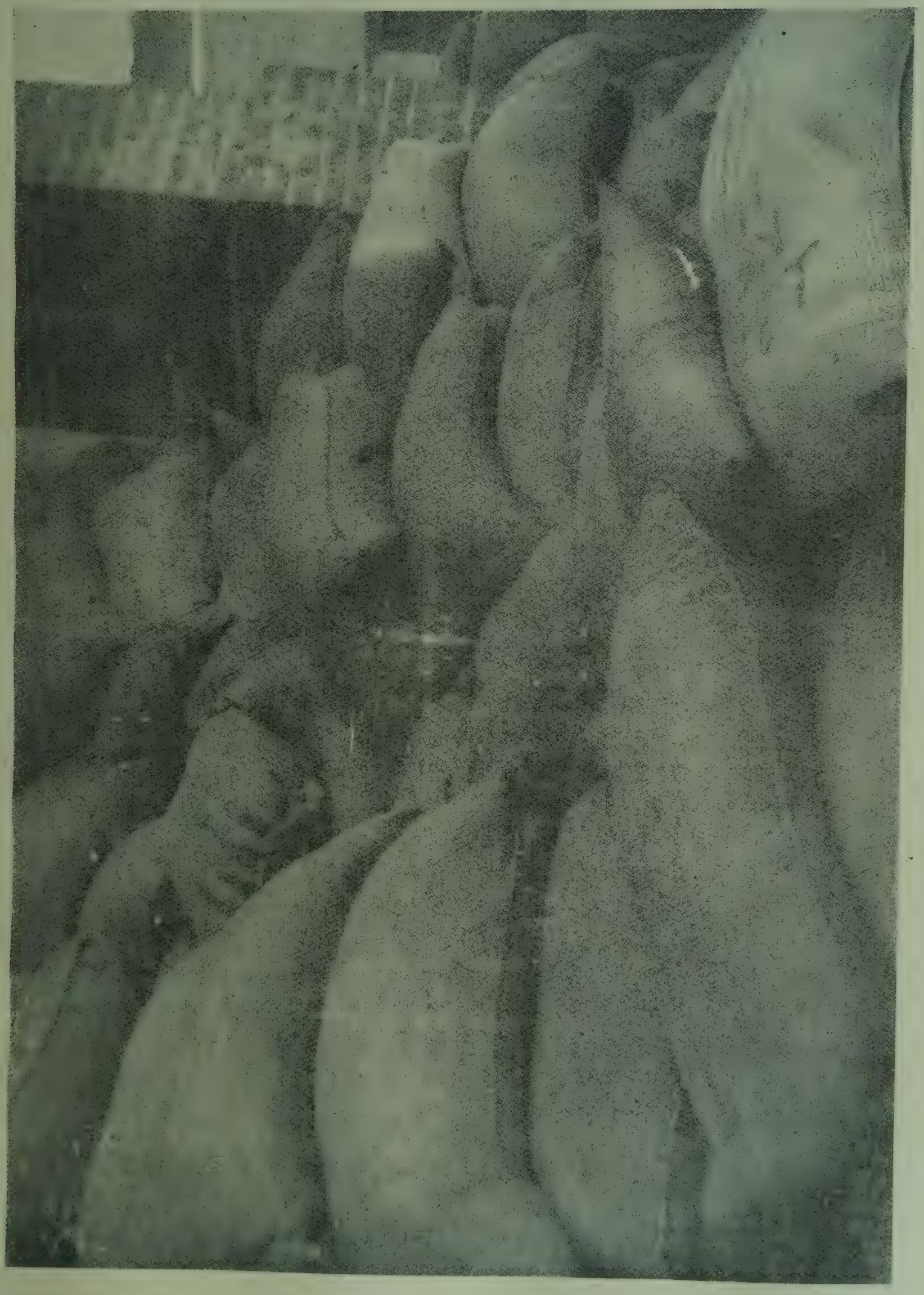

Fig. 3. This is wrong way of stacking bags.

(xii) If any 'heating' or heavy infestation in the bags is discovered, the stocks should be turned over, fumigated and disposed of at the earliest opportunity. The remaining stock should be given particular care as it is unlikely that this will remain free from insects.

(xiii) When moving or receiving the grain from a store, slack bags should be opened and filled; torn ones should be stitched and replaced. Damp or wet bags should be stitched and replaced. Damp grain should be dried and rebagged in dry, clean and uninfested bags. It should also be ensured that transport vehicles are clean and free from insects.

(*b*) *Screening of grain*

Mechanical cleaning (Plate VII) of grain will help in the reduction of pest infestation. This operation should be included in the routine of godown management. The following points should be observed to achieve the best results :—

(i) Screening should be done far away from the stores. If this is not possible due to some local difficulties, all openings of the stores must be kept closed during the cleaning operations.

(ii) Screening machines should be set as far apart as possible.

(iii) 'Screenings' (debris, insects. etc. should be burnt and not be thrown or heaped near about the stores.

(iv) Bags used for disposal of screenings should not be used for cleaned grain.

(v) It should be made certain that there is at least the same number of empty bags in hand as have been opened out for grain cleaning. This is to ensure that *cleaned grain goes into clean bags.*

IV. HOW TO CONTROL INSECT INFESTATION

If dry, cool and uninfested grain is stored in clean and dry receptacles by following the measures described above, the grain will remain practically free from insects, rats, moulds and moisture. If, however, for lack of taking proper precautions, the grain or store gets infested, they can be disinfested by the methods described below :—

(a) Disinfestation of Empty Stores

Fumigation.—The best method of disinfesting an empty store, if it can be made reasonably airtight, is fumigation. The best fumigant for this purpose is hydrogen cyanide. Since this is highly poisonous to human beings, it should be used only by an expert. Hydrogen cyanide fumigation should not be attempted in the indigenous village receptacles which are usually located inside the dwellings.

The next best treatment to destroy insects in empty stores is to liberate inside an insecticidal smoke. These preparations are made of D.D.T. or benzene hexachloride in the form of pallets or ordinary 'bombs'. D.D.T. or benzene hexachloride is put in small pallets or canisters in different sizes, varying from 2 oz. to 1 lb. which are adequate for treatment of 1,000 cubic feet to 10,000 cubic feet of space. Success of smoke treatment depends largely upon the degree to which a store can be made airtight. Improved village and market stores can be effectively treated with D.D.T. or benzene hexachloride smokes. The smoke layer that gets deposited on the walls and ceilings has a residual effect for about two months in the case of D.D.T. and less in the case of benzene hexachloride.

Sprays.—The spray treatment will be possible both in the improved village and *mandi* stores. Three to four per cent. D.D.T. or benzene hexachloride solution in white oil is best. It has a residual effect lasting for about 2—3

PLATE VII

Grain being cleaned over a screening machine used ordinarily by the trade.